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PROCESSING NEEDS AND CONSTRAINTS: NEUTRON DATA PROCESSING

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ABSTRACT

New applications for processed data and increased accuracy requirements have generated needs for change in the Evaluated Nuclear Data Files (ENDF). Some constraints must be removed to allow this growth to take place, but other strong constraints must remain to protect existing users.

ENDF/B started life as a system oriented toward reactor applications, and this philosophy produced a very compact and useful set of files. Its success attracted more applications, and it grew more complex. Although some users find the current version too large, there are three forces acting which will cause the growth of the files to continue. First, the need for increased accuracy (e.g., heating, iron deep penetration); second, new applications (e.g., particle-beam therapy, fusion reactor radiation damage); and third, advanced evaluation methods based on nuclear models which produce more complete, detailed, and consistent information. Our problem during the next few years will be to remove enough constraints to allow ENDF to meet these needs without destroying the usefulness of the files for the old users.

These constraints can be divided into three classes. The first class is the "bookkeeping" constraints such as a maximum of 5000 energy points per section or a maximum of 20 Legendre coefficients for an angular distribution. These rules are designed to protect the memory allocation of the processing codes. Even with sophisticated memory management techniques such as paging, dynamic storage allocation, and parallel data streams, some such restrictions are needed. An apparent need to violate one of

these restrictions may result from an inappropriate representation (e.g., point cross sections instead of resonance parameters) or reflect the need for a new representation (e.g., for diffraction scattering at 20 MeV).

The second class is the "representation" constraints. These are the much more important limitations resulting from the inability to describe a physical process using an ENDF/B format. Sometimes such limitations can be circumvented. An example is the use of "pseudo levels" to represent continuous energy-angle distributions for inelastic scattering. But if ENDF is to meet the needs of the next few years, some of the existing constraints are going to have to be removed by defining new formats. Some of the important problems are discussed below.

Fission Spectrum — A new representation is now available for the energy distribution of fission neutrons as a function of incident neutron energy. The spectrum could be approximated with Watt parameters, entered as a large tabulation, or represented by a new "law." The results should be very important for fission reactors.

Interpolation of Distributions — Two-dimensioned interpolation along the E and E' axes of an energy distribution often gives poor results unless many closely spaced E values are used. A contour scheme or a transformation to better axes might solve the problem.

Energy-Angle Distributions — The correlation of the energy and angle of secondary particles can be measured or estimated using model codes which account for direct processes. Since this effect is important for fast neutron transport, heating, and radiation damage, methods to incorporate energy-angle effects into ENDF should be developed.

Resonance Scattering — Current ENDF/B resonance parameters cannot be used to compute the angular distributions of elastically scattered neutrons. The introduction of an amplitude format might solve this problem and improve the calculation of the transport of fission-spectrum neutrons through iron, nickel, and chromium.

Unresolved Resonance Cross Sections and Covariances — This region is very important for fast reactors, but the cross sections are difficult to compute, and the covariances are not currently defined. Changing to a probability table representation would solve these problems and also improve the consistency between multigroup and Monte Carlo.

Diffraction Scattering — At high energies, elastic and discrete-inelastic angular distributions show strong diffraction

patterns, and many Legendre coefficients are required to represent the distributions. This causes severe problems for multi-group processing codes. Perhaps a new representation could be found which would remove the diffraction part of the scattering and treat it separately, leaving a well-behaved remainder to be represented by the Legendre expansion.

Distributions for Charged Particles — The modern model codes often produce spectra for each product of a neutron reaction, and the distribution of recoils can sometimes be deduced. Most of this information is now lost. If formats for these distributions were added to ENDF, improved heating, damage, and biomedical calculations would be possible.

The third class of constraints is the "judgment" constraints. These are the constraints that can't be quantified and force the evaluator to make tradeoffs between conflicting demands. They can be stated as three rules designed to ensure that ENDF remains an application oriented system.

THE RULE OF CHANGE

Don't make a change in data or formats unless test calculations show that the change will lead to a significant improvement for at least one of the important ENDF applications.

THE RULE OF SIZE

Always use the most compact representation available, and don't add detail unless test calculations show that it is needed for one of the important applications.

THE RULE OF CONSISTENCY

Try to satisfy conservation principles, sum rules, and ratio tests. If an answer can be obtained using two different combinations of data from the file, the results should be as equivalent as possible.

Observing these rules will lead to more work for evaluators, processors, and data testers. But it will help to protect the user; after all, "THE CUSTOMER IS KING."